

We claim:

1. A method of producing elastomer composite, comprising:

feeding a continuous flow of first fluid comprising elastomer latex to a mixing zone of a coagulum reactor defining an elongate coagulum zone extending from the mixing zone to a discharge end;

feeding a continuous flow of second fluid comprising particulate filler under pressure to the mixing zone of the coagulum reactor to form a mixture with the elastomer latex, the mixture passing as a continuous flow to the discharge end and the particulate filler being effective to coagulate the elastomer latex, wherein mixing of the first fluid and the second fluid within the mixing zone is sufficiently energetic to substantially completely coagulate the elastomer latex with the particulate filler prior to the discharge end; and

discharging a substantially continuous flow of elastomer composite from the discharge end of the coagulum reactor.

2. The method of producing elastomer composite in accordance with claim 1 wherein the second fluid is fed to the mixing zone through a nozzle at a velocity of 100 to 800 feet per second.

3. The method of producing elastomer composite in accordance with claim 2 wherein the first fluid is fed continuously into the mixing zone at a velocity lower than 12 feet per second.

4. The method of producing elastomer composite in accordance with claim 1 wherein the elastomer latex is natural rubber latex and the particulate filler is carbon black.

5. The method of producing elastomer composite in accordance with claim 1 further comprising feeding an auxiliary fluid to the mixing zone, the auxiliary fluid being substantially non-reactive with the mixture.

6. The method of producing elastomer composite in accordance with claim 5 wherein the auxiliary fluid is air.

7. The method of producing elastomer composite in accordance with claim 1 wherein the coagulum zone has progressively increasing cross-sectional area in the direction from the mixing zone to the discharge end.

8. A continuous flow method of preparing elastomer composite of particulate filler dispersed in elastomer, comprising:

A) establishing a continuous, semi-confined flow of mixed elastomer latex and particulate filler under pressure in a coagulum reactor forming an elongate coagulum zone extending with progressively increasing cross-sectional area from an entry end to a discharge end, by simultaneously

(i) feeding elastomer latex fluid continuously to a mixing zone at the entry end of the coagulum reactor, and

(ii) entraining the elastomer latex fluid into particulate filler fluid by feeding the particulate filler fluid as a continuous jet into the mixing zone; and

5 B) discharging from the discharge end of the coagulum reactor a substantially constant flow of elastomer composite globules concurrently with feeding of the fluid streams in accordance with steps A(i) and A(ii).

9. The continuous flow method of producing elastomer composite in accordance with claim 8 wherein coagulation of the elastomer latex is substantially complete in the elastomer composite globules as they are discharged from the discharge end of the coagulum reactor.

10. The continuous flow method of producing elastomer composite in accordance with claim 8 further comprising the step of preparing the particulate filler fluid by high energy dispersion of the particulate filler in a liquid in a homogenizer having an outlet port in fluid communication with the mixing zone.

15 11. The continuous flow method of producing elastomer composite in accordance with claim 8 wherein the liquid slurry is fed into the mixing zone through a nozzle at a velocity of 100 to 800 feet per second.

20 12. The continuous flow method of producing elastomer composite in accordance with claim 11 wherein the velocity of the liquid slurry through the nozzle is from 200 to 500 feet per second.

13. The continuous flow method of producing elastomer composite in accordance with claim 8 further comprising the step of premixing minor amounts of additives into the elastomer latex prior to feeding the elastomer latex to the mixing zone.

14. The continuous flow method of producing elastomer composite in accordance with claim 8 wherein the particulate filler fluid is an aqueous carbon black dispersion.

15. The continuous flow method of producing elastomer composite in accordance with claim 8 wherein the particulate filler fluid comprises silicon treated carbon black, fumed silica, precipitated silica, and mixtures of any of them.

16. The continuous flow method of preparing elastomer composite in accordance with claim 8 wherein the elastomer latex fluid consists essentially of natural rubber latex.

17. The continuous flow method of preparing elastomer composite in accordance with claim 16 wherein the natural rubber latex is natural rubber latex concentrate.

18. The continuous flow method of preparing elastomer composite in accordance with claim 16 wherein the natural rubber latex is field latex.

19. The continuous flow method of producing elastomer composite in accordance with claim 8 further comprising mixing additive into the semi-confined flow by separately feeding an additive fluid continuously to the mixing zone simultaneously with the elastomer latex fluid and the particulate filler fluid.

20. The continuous flow method of producing elastomer composite in accordance with claim 8 wherein the additive is selected from antiozonants, antioxidants, plasticizers, processing aids, resins, flame retardants, extender oils, lubricants, and mixtures of any of them.

5 21. The continuous flow method of producing elastomer composite in accordance with claim 8 further comprising injecting pressurized gas into the mixing zone.

22. The continuous flow method of producing elastomer composite in accordance with claim 21 wherein the pressurized gas is injected separately into the mixing zone.

10 23. The continuous flow method of producing elastomer composite in accordance with claim 21 wherein the pressurized gas is injected into the mixing zone through a nozzle together with the particulate filler fluid.

24. The continuous flow method of producing elastomer composite in accordance with claim 8 wherein step A(ii) comprises feeding multiple streams of particulate filler fluid to the mixing zone continuously through multiple nozzles.

15 25. The continuous flow method of producing elastomer composite in accordance with claim 8 further comprising, simultaneously with steps A(i) and A(ii), feeding at least one auxiliary stream of elastomer latex fluid to the mixing zone.

26. The continuous flow method of producing elastomer composite in accordance with claim 8 further comprising the step of drying the elastomer composite globules received from the discharge end of the coagulum reactor, through a dryer.

27. The continuous flow method of producing elastomer composite in accordance with claim 26 further comprising the step of baling the elastomer composite by sequentially compressing 25 to 75 pound quantities of the elastomer composite after the drying step.

28. The continuous flow method of producing elastomer composite in accordance with claim 8 wherein the elastomer latex fluid is fed under pressure less than 10 psig and the particulate filler fluid is fed under pressure of at least 75 psig.

29. A continuous flow method of producing rubber master batch by coagulating natural rubber latex with carbon black, comprising:

A) establishing a continuous, semi-confined flow of mixed natural rubber latex and carbon black in a coagulum reactor forming a generally tubular coagulum zone extending with progressively increasing cross-sectional area from an entry end to an open discharge end, by simultaneously

(i) feeding a liquid stream of the natural rubber latex continuously to a mixing zone at the entry end of the coagulum reactor, and

(ii) entraining the natural rubber latex continuously into a liquid slurry of the carbon black by feeding the liquid slurry as a continuous jet into the mixing zone; and

B) simultaneously discharging rubber master batch globules from the discharge end of the coagulum reactor.

30. A continuous flow method of producing elastomer composite comprising particulate filler selected from carbon black, silicon-treated carbon black, fumed silica, precipitated silica, and mixtures thereof finely dispersed in natural rubber, comprising:

preparing a particulate filler fluid by high energy dispersion of the particulate filler into aqueous liquid in a homogenizer; and

establishing a continuous, semi-confined flow of mixed natural rubber latex and particulate filler in a coagulum reactor forming a generally tubular coagulum zone extending with progressively increasing cross-sectional area from an entry end to a discharge end by simultaneously

(i) feeding a liquid stream of the natural rubber latex at less than 10 feet per second continuously to a mixing zone defined by a mix head in sealed fluid communication with the entry end of the coagulum reactor, the mixing zone extending coaxially with the coagulum zone, and

(ii) entraining the natural rubber latex continuously into the particulate filler fluid by projecting the particulate filler fluid into the mixing zone in the direction of the entry end of the coagulum zone, through a feed tube substantially coaxial with the coagulum zone, the particulate filler fluid exiting the feed tube at a velocity of 200 to 500 feet per second;

simultaneously and continuously discharging from the discharge end of the coagulum reactor master batch globules in which coagulation of the natural rubber latex by the particulate filler is substantially complete; and

simultaneously and continuously drying and pelletizing master batch globules discharged from the coagulum reactor in at least one dryer.

31. Apparatus for producing elastomer composite of particulate filler dispersed in elastomer, comprising:

5 a coagulum reactor defining a mixing zone and an elongate coagulum zone extending from the mixing zone to a discharge end;

latex feed means for feeding elastomer latex fluid continuously to the mixing zone; and

10 filler feed means for feeding particulate filler fluid as a continuous jet into the mixing zone to form a mixture with the elastomer latex fluid traveling from the mixing zone to the discharge end of the coagulum zone, wherein the distance between the mixing zone and the discharge end is sufficient to permit substantially complete coagulation of the elastomer latex prior to the discharge end.

15 32. The apparatus for producing elastomer composite in accordance with claim 31 wherein the filler feed means is for feeding particulate filler fluid continuously to the mixing zone through a nozzle at a velocity of 100 to 600 feet per second.

33. The apparatus for producing elastomer composite in accordance with claim 32 wherein the latex feed means is for feeding elastomer latex fluid continuously into the mixing zone at a velocity less than 8 feet per second.

34. The apparatus for producing elastomer composite in accordance with claim 31 wherein the filler feed means is for feeding particulate filler fluid continuously to the mixing zone under pressure of at least 75 pounds per square inch (gauge).

35. The apparatus for producing elastomer composite in accordance with claim 34 wherein the latex feed means is for feeding elastomer latex fluid continuously into the mixing zone under pressure less than 12 pounds per square inch.

36. The apparatus for producing elastomer composite in accordance with claim 31 further comprising auxiliary feed means for simultaneously feeding an additional stream of pressurized fluid to the mixing zone.

37. The apparatus for producing elastomer composite in accordance with claim 36 wherein the pressurized fluid is air.

38. The apparatus for producing elastomer composite in accordance with claim 31 wherein the coagulum zone has progressively increasing cross-sectional area between the mixing zone and the discharge end.

39. Apparatus for continuous flow production of elastomer composite of particulate filler dispersed in elastomer, comprising:

a coagulum reactor forming an elongate coagulum zone extending with progressively increasing cross-sectional area from an entry end toward a discharge end;

means for feeding elastomer latex fluid continuously to a mixing zone at the entry end of the coagulum reactor; and

means for feeding particulate filler fluid sufficiently energetically into the mixing zone to create semi-confined flow of mixed elastomer latex and particulate filler in the coagulum zone toward the discharge end and achieve substantial coagulation of the elastomer latex with the particulate filler prior to the discharge end.

40. Apparatus for producing elastomer composite of particulate filler dispersed in elastomer, comprising:

a coagulum reactor forming an elongate coagulum zone extending with progressively increasing cross-sectional area from an entry end to a discharge end;

means for feeding elastomer latex fluid continuously to a mixing zone at the entry end of the coagulum reactor; and

means for feeding to the mixing zone a continuous jet of particulate filler fluid, under pressure, effective to entrain elastomer latex fluid into a mixture with the particulate filler fluid and to substantially completely coagulate the elastomer latex with the particulate filler prior to the mixture arriving at the discharge end.

41. The apparatus for continuous flow production of elastomer composite in accordance with claim 40 wherein the mixing zone is within a mix head and is substantially coaxial with the elongate coagulum zone.

42. The apparatus for continuous flow production of elastomer composite in accordance with claim 41 wherein the mix head is sealed to a coagulum zone extender.

43. The apparatus for continuous flow production of elastomer composite in accordance with claim 42 wherein the means for feeding a stream of particulate filler fluid comprises a first feed tube extending substantially coaxially within the mixing zone to a slurry nozzle tip open toward the coagulum zone.

44. The apparatus for continuous flow production of elastomer composite in accordance with claim 43 wherein:

the mix head forms a first feed channel substantially coaxial with the coagulum zone, extending from an entry port toward the coagulum zone; and

the first feed tube extending coaxially within the first feed channel forms a fluid tight seal with the mix head at the entry port.

45. The apparatus for continuous flow production of elastomer composite in accordance with claim 44 wherein the first feed tube extends from the entry port to a slurry nozzle tip and wherein a constant diameter land within the first feed tube immediately upstream of the slurry nozzle tip has an axial dimension at least three times its diameter.

46. The apparatus for continuous flow production of elastomer composite in accordance with claim 44 wherein the means for feeding elastomer latex fluid comprises a second feed channel formed by the mix head at an angle of 30° to 90° to the first feed

channel, extending to a junction with the mixing zone from a second entry port remote from the mixing zone.

47. The apparatus for continuous flow production of elastomer composite in accordance with claim 45 wherein the cross-sectional area of the coagulum zone immediately downstream of the mixing zone is more than twice the cross-sectional diameter of the first feed tube.

48. The apparatus for continuous flow production of elastomer composite in accordance with claim 47 wherein the cross-sectional area of the coagulum zone immediately downstream of the mixing zone is about 4 to 8 times the cross-sectional area of the first feed tube.

49. The apparatus for continuous flow production of elastomer composite in accordance with claim 45 wherein the mix head forms at least one additional feed channel at an angle of 30° to 90° to the first feed channel, extending to a junction with the mixing zone from an entry port remote from the mixing zone.

50. The apparatus for continuous flow production of elastomer composite in accordance with claim 40 wherein at least a first portion of the coagulum zone extending from the entry end toward the discharge end has a circular cross-section and a central longitudinal axis, the circular cross-section increasing in size at an overall angle greater than zero degrees and less than 25 degrees to the central longitudinal axis.

51. The apparatus for continuous flow production of elastomer composite in accordance with claim 40 wherein the cross-sectional area of the coagulum zone increases continuously toward the discharge end.

52. The apparatus for continuous flow production of elastomer composite in accordance with claim 50 wherein the cross-sectional area of the coagulum zone increases step-wise from the entry end toward the discharge end.

53. The apparatus for continuous flow production of elastomer composite in accordance with claim 51 wherein said first portion of the coagulum zone comprises:

a first section of substantially constant diameter D_1 extending a length L_1 from the entry end toward the discharge end, L_1 being at least three times D_1 , and

multiple additional sections each having substantially constant cross-sectional diameter, at least twice the cross-sectional area of an immediately preceding section, and a length equal to at least three times its cross-sectional diameter.

54. The apparatus for continuous flow production of elastomer composite in accordance with claim 53 wherein the length L_1 of the first section is about 12 to 18 times its diameter D_1 .

55. The apparatus for continuous flow production of elastomer composite in accordance with claim 54 wherein the coagulum zone extending from the entry end

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toward the discharge end has circular cross-section, increases in size step-wise toward the discharge end, and has:

5 a first section beginning at the entry end having a substantially constant cross-sectional diameter D_1 equal to 5 to 8 times the cross-sectional diameter of the nozzle, a cross-sectional area A_1 , and a length L_1 which is 12 to 18 times D_1 ;

a second section extending toward the discharge end from a faired connection to the first section, having a substantially constant cross-sectional diameter D_2 , a cross-sectional area A_2 approximately two times A_1 , and a length L_2 approximately three to seven times D_2 ;

10 a third section extending toward the discharge end from a faired connection to the second section, having a substantially constant cross-sectional diameter D_3 , a cross-sectional area A_3 approximately two times A_2 , and a length L_3 approximately three to seven times D_3 ; and

15 a fourth section extending toward the discharge end from a faired connection to the third section, having a substantially constant cross-sectional diameter D_4 , a cross-sectional area A_4 approximately two times A_3 , and a length L_4 approximately three to seven times D_4 .

20 56. The apparatus for continuous flow production of elastomer composite in accordance with claim 40 further comprising a diverter for receiving elastomer composite from the discharge end of the coagulum zone and passing the elastomer composite selectively to any of multiple receiving sites.

57. The apparatus for continuous flow production of elastomer composite in accordance with claim 56 wherein the diverter comprises a flexible conduit having a first end attached to the discharge end of the coagulum reactor and a second end moveable to any of the multiple receiving sites.

5 58. The apparatus for continuous flow production of elastomer composite in accordance with claim 56 wherein the means for feeding particulate filler fluid comprises pumping means for developing said pressure to greater than 75 psig and the means for feeding elastomer latex fluid comprises a holding tank and feed line for developing less than 10 psig elastomer latex fluid pressure.

10 59. The apparatus for continuous flow production of elastomer composite in accordance with claim 40, wherein the particulate filler fluid is carbon black slurry comprising carbon black in a carrier liquid, further comprising carbon black slurry preparation means in fluid communication with the means for feeding particulate filler fluid to the mixing zone, comprising:

15 a mixing tank for agitated mixture of carbon black and carrier liquid, having a discharge port for discharging a mixture fluid;

a colloid mill for dispersing carbon black in the carrier liquid to form a dispersion fluid, having an intake port in fluid communication with the discharge port of the mixing tank and an outlet port for discharging the dispersion fluid; and

20 an homogenizer for more finely dispersing the carbon black in the carrier liquid to form the carbon black slurry, having an inlet port in fluid communication

with the discharge port of the colloid mill and an exit port for passing carbon black slurry to the means for feeding particulate filter fluid to the mixing zone.

60. An elastomer composite comprising elastomer in which particulate filler has been dispersed by:

5 feeding a continuous flow of first fluid comprising elastomer latex to a mixing zone of a coagulum reactor defining an elongate coagulum zone extending from the mixing zone to a discharge end;

10 feeding a continuous flow of second fluid comprising particulate filler under pressure to the mixing zone of the coagulum reactor to form a mixture with the elastomer latex, the mixture passing as a continuous flow to the discharge end, and the particulate filler being effective to coagulate the elastomer latex, wherein mixing of the first fluid and the second fluid within the mixing zone is sufficiently energetic to substantially completely coagulate the elastomer latex with the particulate filler prior to the discharge end; and

15 discharging a substantially continuous flow of elastomer composite from the discharge end of the coagulum reactor.

61. An elastomer composite comprising particulate filler finely dispersed in elastomer, formed by a continuous flow method comprising the steps of:

20 A) establishing a continuous, semi-confined flow of mixed elastomer latex and particulate filler under pressure in a coagulum reactor forming an elongate coagulum zone extending with progressively increasing cross-sectional area from an entry end to a discharge end, by simultaneously

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(i) feeding elastomer latex fluid continuously to a mixing zone at the entry end of the coagulum reactor, and

(ii) entraining the elastomer latex fluid into particulate filler fluid by feeding the particulate filler fluid as a continuous jet into the mixing zone;

and

B) discharging from the discharge end of the coagulum reactor a substantially constant flow of elastomer master batch globules concurrently with feeding of the fluid streams in accordance with steps A(i) and A(ii).

An elastomer composite formed by a continuous flow method comprising the steps

of:

A) establishing a continuous semi-confined flow of mixed natural rubber latex and carbon black in a coagulum reactor forming a generally tubular coagulum zone extending with progressively increasing cross-sectional area from an entry end to an open discharge end, by simultaneously

(i) feeding a liquid stream of the natural rubber latex continuously to a mixing zone at the entry end of the coagulum reactor, and

(ii) entraining the natural rubber latex continuously into a liquid slurry of the carbon black by feeding the liquid slurry as a continuous jet into the mixing zone; and

B) simultaneously discharging elastomer composite globules from the discharge end of the coagulum reactor.

63. An elastomer composite formed by a continuous flow method comprising the following steps:

preparing a particulate filler fluid by high energy dispersion of the particulate filler into aqueous liquid in a homogenizer; and

5 establishing a continuous, semi-confined flow of mixed natural rubber latex and particulate filler in a coagulum reactor forming a mixing zone and a generally tubular coagulum zone extending with progressively increasing cross-sectional area from the mixing zone to a discharge end by simultaneously

10 (i) feeding a liquid stream of the natural rubber latex at less than 10 feet per second continuously to a mixing zone defined by a mix head in sealed fluid communication with a coagulum zone extender, the mixing zone extending coaxially with the coagulum zone, and

15 (ii) entraining the natural rubber latex continuously into the particulate filler fluid by feeding the particulate filler fluid into the mixing zone through a feed tube substantially coaxial with the coagulum zone, the particulate filler fluid exiting the feed tube at a velocity of 200 to 500 feet per second;

20 simultaneously and continuously discharging from the discharge end of the coagulum reactor globules of the elastomer composite in which coagulation of the natural rubber latex by the particulate filler is substantially complete; and

simultaneously and continuously drying and pelletizing globules discharged from the coagulum reactor.

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45 64. An elastomer composite comprising particulate filler dispersed in elastomer, the macro-dispersion D(%) of the particulate filler in the elastomer composite being less than 0.2% undispersed area.

6 65. The elastomer composite of claim ⁵64 wherein the particulate filler is carbon black, silicon coated carbon black, silicon treated carbon black, fumed silica, precipitated silica or a mixture of any of them.

7 66. The elastomer composite of claim ⁵64 wherein the elastomer is natural rubber, a chlorinated derivative of natural rubber, or a homopolymer, copolymer or terpolymer of butadiene, styrene, isoprene, isobutylene, 3,3-dialkyl-1, 3-butadiene where the alkyl group is C1 to C3 alkyl, acrylonitrile, ethylene or propylene.

8 67. An elastomer composite comprising at least 30 phr particulate filler dispersed in elastomer, the particulate filler being selected from carbon black, silicon coated carbon black, silicon treated carbon black, fumed silica, precipitated silica or a mixture of any of them and the elastomer being selected from natural rubber, or a homopolymer, copolymer or terpolymer of butadiene, styrene, isoprene, isobutylene, 3,3-dialkyl-1, 3-butadiene where the alkyl group is C1 to C3 alkyl, acrylonitrile, ethylene or propylene, wherein macro-dispersion D(%) of the particulate filler in the elastomer composite ^{is} being less than 0.2% undispersed area.

9 ~~68~~. The elastomer composite of claim ~~67~~⁸ further comprising at least one additive selected from antizonants, antioxidants, plasticizers, processing aids, resins, flame retardants, extender oils, lubricants, and mixtures of any of them.

10 ~~69~~. The elastomer composite of claim ~~67~~⁸ wherein the macro-dispersion D(%) is less
5 than .1% undispersed area.

11 ~~70~~. An elastomer composite comprising natural rubber and 30 to 75 phr carbon black having structure and surface area ratio DBPA: CTAB less than 1.2, having macro-dispersion D(%) no greater than 0.3%.

12 ~~71~~. The elastomer composite of claim ~~70~~¹¹ wherein the carbon black has structure and
10 surface area ratio DBPA: CTAB less than 1.0.

13 ~~72~~. An elastomer composite comprising carbon black dispersed in natural rubber, the macro-dispersion D(%) of the carbon black in the elastomer composite being less than 0.2% undispersed area.

14 ~~73~~. The elastomer composite of claim ~~72~~¹³ wherein the macro-dispersion D(%) of the
15 carbon black in elastomer composite, measured as percent undispersed area for defects larger than 10 microns, is less than .1%.

15 ~~74~~. The elastomer composite of claim ¹³~~72~~ wherein the elastomer composite is unvulcanized and the MW_{sol} (weight average) of the elastomer composite is at least .45 x 10⁶.

16 ~~75~~. The elastomer composite of claim ¹³~~72~~ wherein the carbon black has surface area
5 CTAB greater than 45.

17 ~~76~~. The elastomer composite of claim ¹³~~72~~ wherein the elastomer composite comprises at least 30 phr carbon black.

18 ~~77~~. The elastomer composite of claim ¹³~~72~~ further comprising from 0 to 20 phr extender oil.

10 19 ~~78~~. An elastomer composite comprising carbon black dispersed in natural rubber, the carbon black having structure and surface area properties of Region I of Fig. 8, wherein the elastomer composite has MW_{sol} and macro-dispersion D(%) in the area below line 101 in Fig. 10.

20 ~~79~~. An elastomer composite comprising carbon black dispersed in natural rubber, the
15 carbon black having structure and surface area properties of Region II of Fig. 8, wherein the elastomer composite has MW_{sol} and macro-dispersion D(%) in the area below line 111 in Fig. 11.

21 80. An elastomer composite comprising carbon black dispersed in natural rubber, the carbon black having structure and surface area properties of Region III of Fig. 8, wherein the elastomer composite has MW_{sol} and macro-dispersion $D(\%)$ in the area below line 121 in Fig. 12.

5 22 81. An elastomer composite comprising natural rubber, 30 to 75 phr carbon black having surface area of CTAB from 45 to less than 250 and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion $D(\%)$ of the carbon black in the natural rubber, as follows:

(i) $D(\%) \leq .2\%$

10 when $MW_{sol} \leq .45 \times 10^6$; and

(ii) $\log(D) \leq \log(0.2) + 2.0 \times (MW_{sol} - 0.45 \times 10^6) \times 10^{-6}$

when $.45 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

23 82. An elastomer composite comprising natural rubber, 30 to 75 phr carbon black having surface area of CTAB of 45 to 250 and structure of DBPA (cc/100g) less than 110 where CTAB is greater than 65 and less than 250, and DBPA less than $80 + 1.6(CTAB - 45)$ where CTAB is from 45 to less than 65, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion $D(\%)$ of the carbon black in the natural rubber, as follows:

(i) $D(\%) < 1.0\%$

20 when MW_{sol} is less than 0.7×10^6 ; and

(ii) $\log(D) < \log 1.0 + 2.5 \times (MW_{sol} - 0.7 \times 10^6) \times 10^{-6}$

when $0.7 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

24 83. An elastomer composite comprising natural rubber, 30 to 70 phr carbon black having structure DBPA from 110 to less than 80 + 1.6 (CTAB - 45), and surface area of CTAB greater than 65 and less than 250, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion D(%) of the carbon black in the natural rubber, as follows:

(i) $D < 0.3\%$

when MW_{sol} is less than $.35 \times 10^6$; and

(ii) $\log(D) < \log(0.3) + 2.8(MW_{sol} - .35 \times 10^6) \times 10^{-6}$

when $.35 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

10 25 84. An elastomer composite comprising natural rubber and 40 to 70 phr carbon black having structure DBPA (cc/100g) from 80 + 1.6 (CTAB - 45) to 160, and surface area CTAB from 45 to less than 90, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion D(%) of the carbon black in the natural rubber as follows:

(i) $D(\%) < 0.1\%$

15 when MW_{sol} is less than 0.35×10^6 ; and

(ii) $\log(D) < \log(0.1) + 2.0 \times (MW_{sol} - 0.30 \times 10^6) \times 10^{-6}$

when $0.3 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

26 85. An elastomer composite comprising natural rubber, 30 to 70 phr STERLING® 6740 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion D(%) of the carbon black in the natural rubber, as follows:

(i) $D(\%) < 0.1\%$

when MW_{sol} is less than 0.3×10^6 ; and

(ii) $\log(D) < \log(0.1) + 2.0 \times (MW_{sol} - 0.3 \times 10^6) \times 10^{-6}$

when $0.3 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

27 ~~86~~. An elastomer composite comprising natural rubber, 30 to 70 phr N234 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion

5 D(%) of the carbon black in the natural rubber, as follows:

(i) $D(\%) < 0.3\%$

when MW_{sol} is less than 0.35×10^6 ; and

(ii) $\log(D) < \log(0.3) + 2.8 (MW_{sol} - 0.35 \times 10^6) \times 10^{-6}$

when $0.35 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

10 28 ~~87~~. An elastomer composite comprising natural rubber, 30 to 70 phr N110 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion D(%) of the carbon black in the natural rubber as follows:

(i) $D(\%) < 0.5\%$

when MW_{sol} is less than 0.35×10^6 ; and

15 (ii) $\log(D) < \log(0.5) + 2.5 \times (MW_{sol} - 0.35 \times 10^6) \times 10^{-6}$

when $0.35 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

29 ~~88~~. An elastomer composite comprising natural rubber, 30 to 70 phr N326 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion D(%) of the carbon black in the natural rubber as follows:

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(i) $D(\%) < 1.0\%$

when MW_{sol} (weight average) is less than 0.7×10^6 ; and

(ii) $\log(D) < \log(1.0) + 2.5 \times (MW_{sol} - 0.7 \times 10^6) \times 10^{-6}$

when $0.7 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

5 30 ~~89~~. An elastomer composite comprising natural rubber, 30 to 70 phr BLACK PEARL
® 800 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-
dispersion $D(\%)$ of the carbon black in the natural as follows:

(i) $D(\%) < 1.5\%$

when MW_{sol} is less than 0.65×10^6 ; and

10 (ii) $\log(D) < \log(1.5) + 2.5 \times (MW_{sol} - 0.65 \times 10^6) \times 10^{-6}$

when $0.65 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

31 ~~90~~. An elastomer composite comprising natural rubber, 30 to 70 phr REGAL ® 660
carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-
dispersion $D(\%)$ of the carbon black in the natural rubber as follows:

15 (i) $D(\%) < 1.0\%$

when MW_{sol} is less than 0.6×10^6 ; and

(ii) $\log(D) < \log(1.0) + 2.5 \times (MW_{sol} - 0.6 \times 10^6) \times 10^{-6}$

when $0.6 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

32 ~~91~~. An elastomer composite comprising natural rubber, 30 to 70 phr REGAL ® 250
20 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-
dispersion $D(\%)$ of the carbon black in the natural rubber as follows:

(i) $D(\%) < 1.0\%$

when MW_{sol} is less than 0.6×10^6 ; and

$$(ii) \quad \log(D) < \log(1.0) + 2.5 \times (MW_{sol} - 0.6 \times 10^6) \times 10^{-6}$$

when $0.6 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

53392. An elastomer composite comprising natural rubber, 30 to 70 phr N330 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion D(%) of the carbon black in the natural rubber as follows:

(i) $D(\%) < 1.0\%$

when MW_{sol} is less than 0.6×10^6 ; and

$$10 \quad \text{(ii)} \quad \log(D) < \log(1.0) + 2.5 \times (\text{MW}_{\text{sol}} - 0.6 \times 10^6) \times 10^{-6}$$

when $0.6 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

3.4 ~~ex.~~ An elastomer composite comprising natural rubber, 30 to 70 phr N351 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion D(%) of the carbon black in the natural rubber as follows:

15 (i) $D(\%) < 0.3\%$

when MW_{sol} is less than 0.55×10^6 ; and

$$(ii) \quad \log(D) < \log(0.3) + 2.0 \times (MW_{\text{sol}} - 0.55 \times 10^6) \times 10^{-6}$$

when $0.55 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

35 4. An elastomer composite comprising natural rubber, 30 to 70 phr particulate filler
20 comprising a blend of carbon black and silica, and 0 to 20 phr extender oil, the elastomer

composite having macro-dispersion D(%) of the particulate filler in the natural rubber as follows:

(i) $D(\%) < 0.8\%$

when MW_{sol} is less than 0.5×10^6 ; and

5 (ii) $\log(D) < \log(0.8) + 2.2 \times (MW_{sol} - 0.5 \times 10^6) \times 10^{-6}$

when $0.5 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

36 ~~95~~ The elastomer composite of claim ³⁵94 wherein the particulate filler comprises at least about 60% carbon black.

37 ~~96~~ An elastomer composite comprising natural rubber, 30 to 70 phr silicon-treated
10 carbon black, and 0 to 20 phr extender oil, the elastomer composite having macro-dispersion D(%) of the silicon-treated carbon black in the natural rubber as follows:

(i) $D(\%) < 1.0\%$

when MW_{sol} is less than 0.4×10^6 ; and

(ii) $\log(D) < \log(1.0) + 2.0 \times (MW_{sol} - 0.4 \times 10^6) \times 10^{-6}$

15 when $0.4 \times 10^6 < MW_{sol} < 1.1 \times 10^6$.

38 ~~97~~ A vulcanizate comprising carbon black dispersed in natural rubber, the macro-dispersion D(%) of the carbon black in the elastomer composite being less than 0.2%.

39 ~~98~~ A vulcanizate of claim ³⁸97 wherein the macro-dispersion D(%) of the carbon black
in the elastomer composite is less than 0.1%.

40 99. Cured elastomer composite in accordance with claim ~~97~~. 38

41 100. Tire tread comprising cured elastomer composite in accordance with claim ~~99~~. 40

42 101. Tire sub-tread comprising cured elastomer composite in accordance with claim ~~99~~. 40

43 102. Wire-skim for a tire comprising elastomer composite in accordance with claim ~~99~~. 40

5.44 103. Tire sidewall comprising elastomer composite in accordance with claim ~~99~~. 40

45 104. Cushion gum for a re-tread tire, comprising elastomer composite in accordance with claim ~~99~~. 40

46 105. A rubber component of an engine mount, comprising elastomer composite in accordance with claim ~~99~~. 40

10 47 106. Tank track comprising elastomer composite in accordance with claim ~~99~~. 40

48 107. Mining belt, comprising elastomer composite in accordance with claim ~~99~~. 40

49 108. A rubber component of a hydro-mount comprising elastomer composite in accordance with claim ~~99~~. 40

50 109. A bridge bearing comprising elastomer composite in accordance with claim 99. 40

51 110. A seismic isolator comprising elastomer composite in accordance with claim 99. 40

52 111. Cured elastomer composite in accordance with claim 97 38 having a crack growth rate measured in accordance with ASTM D3629-94 no more than 1.20cm/million cycles. 5

112. A vulcanizate having a crack growth rate measured in accordance with ASTM D3629-94 of no more than about 1.20 cm / million cycles.

113. A method of producing elastomer composite, comprising:

10 feeding a flow of first fluid comprising elastomer latex to a mixing zone of a coagulum reactor defining an elongate coagulum zone extending from the mixing zone to a discharge end;

SUB 32
15 feeding a flow of second fluid comprising particulate filler under pressure to the mixing zone of the coagulum reactor to form a mixture with the elastomer latex, the mixture passing as a continuous flow to the discharge end and the particulate filler being effective to coagulate the elastomer latex, wherein mixing of the first fluid and the second fluid ^{is fed to} within the mixing zone ^{is} sufficiently ^{energetically} ~~energetic~~ to substantially completely coagulate the elastomer latex with the particulate filler prior to the discharge end; and

20 discharging a flow of elastomer composite from the discharge end of the coagulum reactor.